

AD 731 859

TECHNICAL REPORT

1/1/71 - 6/30/71

CENTER FOR COMPUTER-BASED BEHAVIORAL STUDIES

Department of Psychology

University of California, Los Angeles

Reproduced by  
**NATIONAL TECHNICAL  
INFORMATION SERVICE**  
Springfield, Va. 22151

AUG 12 1971  
100-111150  
D

This research is supported by the  
Advanced Research Projects Agency  
of the Department of Defense  
and is monitored by  
Rome Air Development Center  
under Contract No. F30602-70-C-0016

**DISTRIBUTION STATEMENT A**  
Approved for public release;  
Distribution Unlimited

42

# DISCLAIMER NOTICE

THIS DOCUMENT IS THE BEST  
QUALITY AVAILABLE.

COPY FURNISHED CONTAINED  
A SIGNIFICANT NUMBER OF  
PAGES WHICH DO NOT  
REPRODUCE LEGIBLY.

Unclassified

Security Classification

## DOCUMENT CONTROL DATA - R &amp; D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) Center for Computer-based Behavioral Studies UCLA - Dept. of Psychology 405 Hilgard, Los Angeles, California 90024		2a. REPORT SECURITY CLASSIFICATION Unclassified
3. REPORT TITLE CENTER FOR COMPUTER-BASED BEHAVIORAL STUDIES: Fourth Semi-annual Technical Report on Contract F30602-70-C-0016 ARPA Order No. 1488		
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Technical Report - 1/1/71-6/30/71		
5. AUTHOR(S) (First name, middle initial, last name)		
6. REPORT DATE July 31, 1971	7a. TOTAL NO. OF PAGES	7b. NO. OF PAGES
8a. CONTRACT OR GRANT NO. F30602-70-C-0016	9a. ORIGINATOR'S REPORT NUMBER(S) TR 7/31/71	
8b. PROJECT NO. EMK/1	9b. OTHER REPORT NUMBER(S) (Any other numbers that may be assigned this report)	
10. DISTRIBUTION STATEMENT Distribution of this document is unlimited.		
11. SUPPLEMENTARY NOTES		12. SPONSORING MILITARY ACTIVITY Rome Air Development Center Griffiss AFB, New York 13440
13. ABSTRACT The Center for Computer-based Behavioral Studies (CCBS) on the UCLA campus is designed and will be developed to overcome a number of the methodological limitations blocking significant research advances in, and behavioral sciences contributions to, the study and analysis of national policies and problems. The Center is to be designed around a time-shared computer system that will make its informational and technological resources available to behavioral scientists and policy analysts located at widely dispersed university and research centers, offering them new and powerful research, policy planning, and educational tools. A number of these tools for studying and analyzing the behavior of individuals, groups, and social-political units are specifically relevant to help bridge the enormous gap that continues to exist between the policy analyst and the behavioral scientist. An essential part of the development of these broad methodological and technological areas is an ongoing program of substantive research on bargaining and conflict resolution behavior relevant to political crisis management. With the three areas of development (laboratory gaming and simulation research, inductive data analysis, and data resources management) sharing a common and systematic base of operation, the potentials for mutual support among them will be substantially enhanced. Central to all of these activities are plans based on a number of highly integrated software systems, hardware configurations, and laboratory design and equipment requirements, stemming from ARPA-supported research and development projects conducted over the past six years. ( )		

DD FORM 1473 (PAGE 1)

S/N 0101-807-6801

Security Classification

TECHNICAL REPORT

1/1/71 - 6/30/71

RADC TR Number:

ARPA Order Number: 1488

Program Code Number: 1488

Amount of Contract: \$4,448,799

Contract Number: F30602-70-C-0016

Name of Contractor: The Regents of the University of California

Date of Contract: 1 July 1969

Contract Expiration Date:

Principal Investigator: Gerald H. Shure, Ph.D.

Project Scientists: Gerald H. Shure, Ph.D.  
Phone: (213) 825-2698

Robert J. Meeker  
Phone: (213) 825-5274

Alvin S. Cooperband  
Phone: (213) 825-7506

Short Title of Work: CENTER FOR COMPUTER-BASED BEHAVIORAL STUDIES

Sponsored by Advanced Research Projects Agency  
ARPA Order Number 1488

DISTRIBUTION OF THIS DOCUMENT IS UNLIMITED

# TABLE OF CONTENTS

	Page
ABSTRACT.....	ii
OVERVIEW OF THE REPORT.....	1
PROGRESS ON PROJECT: 1 JULY 1969 THROUGH 30 JUNE 1971.....	5
Computer laboratory support system.....	8
Specification and acquisition of Computing system hardware.....	9
Specification and acquisition of Computing system software.....	12
Laboratory facility design and implementation.....	17
Data management and analysis systems developments.....	21
TRACE--data management developments....	21
IDEA--inductive analysis developments..	22
Data resource management--archive developments.....	24
Simulation research and methodology development.....	26
Scenario topics, conceptual issues, and scenario developments.....	27
Computer methodology developments.....	42
All computer simulation modelling of international conflict.....	48
Experimental and para-laboratory research studies of human behavior in situational conflict.....	50
FUTURE PLANS.....	57
PROFESSIONAL AND PROJECT-RELATED ACTIVITIES.....	64
Professional conferences and presentations.....	64
Project documentation, January - June 1971.....	66

## ABSTRACT

The Center for Computer-based Behavioral Studies (CCBS) on the UCLA Campus is designed and is being developed to overcome a number of the methodological limitations blocking significant research advances in, and behavioral sciences' contributions to, the study of national policies and problems. The Center is designed around a time-shared computer system that will make its informational and technological resources available to behavioral scientists and policy analysts located at widely dispersed university and research centers, offering them new and powerful research, policy planning, and educational tools. A number of these tools for studying and analyzing the behavior of individuals, groups, and social-political units are specifically capable of narrowing the enormous gap that continues to exist between the policy analyst and the behavioral scientist. Essential to the development of these broad methodological and technological areas is an ongoing program of substantive research on bargaining and conflict resolution behavior relevant to political crisis management. As the three areas of development (laboratory gaming and simulation research, inductive data analysis, and data resources management) share a systematic base of operation, the potentials for mutual support among them will be substantially enhanced. Central to all of these activities are plans based on a number of highly integrated software systems; hardware configurations, and laboratory design and equipment requirements, stemming from ARPA-supported research and development projects conducted over the past seven years.

This document reports on project developments in the first two years, and describes plans for project developments for the balance of the contract period. (As an aid to the reader who may not have past documentation close at hand, the document as a whole, and many of the internal sections, are prefaced by an overview statement which reflects the general background and rationale developed in the original proposal.)

## OVERVIEW

The events of the sixties have underscored the general failure of the behavioral sciences to contribute significantly to the solution of the pressing problems of the day, or to offer guidance to the decision makers who face these problems. In the outspoken view of a national advisory committee on the behavioral sciences, there is a "lack of vital social and economic information on critical issues and lack of methods for analyzing information and relating it to policies and operations."\*

While there is a growing recognition of the relevance of the behavioral sciences to the range of complex decisions facing the government in domestic and foreign affairs, it has not immediately produced a new wave of social science research. The university scientists of the country have moved slowly in facing these large-scale problems. Part of their reticence stems from the realization that new research directions require new methods and information resources that are beyond the capabilities of individual researchers within most university research communities.

This document describes the plans for a Center for Computer-based Behavioral Studies (CCBS) on the UCLA Campus--its design, phased development, and use. The Center is designed around a time-shared computer system that will make its informational and technological resources available to behavioral scientists located at widely dispersed university and research centers, offering them new and powerful research, policy planning, and educational tools. The Center will provide resources that will allow behavioral scientists to extend their knowledge and basic research interests to the study and analysis of national policies and problems. A number of these tools for studying and analyzing the behavior of individuals, groups, and social-political units are specifically relevant to

---

\* "Report on the Behavioral Sciences and the Federal Government," American Psychologist, 23:11 (1968), p. 803.

help bridge the enormous gap that continues to exist between the policy analyst and the behavioral scientist, who prefers to engage in those forms of research which yield more readily to reductionist theories and existing research techniques.

The broad range of needed support can be cast into three generally defined areas:

- . Laboratory Gaming and Behavioral Simulation Research. The aim is to provide necessary laboratory techniques so that problems embedded in real-world complexity can be studied intensively and rigorously in a controlled laboratory environment. A laboratory program is designed to break through some of the methodological limitations that currently threaten the viability of laboratory simulation for use as a tool in both theory building and policy study. A variety of laboratory techniques will be developed for using the computer as an experimental tool for on-line analysis, umpiring, controlling, and recording of decision-making behavior, particularly the dynamic interaction process that takes place between players and teams of players. A primary focus of such development will be to provide support for complex, multiperson simulations.
- . Inductive Data Analysis. The need is to develop more effective tools for exploratory and inductive analysis of data that are not well understood and that may be derived from situations that do not fit the tightly structured paradigms of traditional research designs. As the sources of data become larger, more complex, and more open-ended (whether from the growing role of induction in laboratory studies or from the increased use and availability of real-world data archives), the researcher will need new means of exploring, manipulating, and analyzing these data.
- . Data Resources Management. The need is to develop a data resource system and associated data repository to be based on the most advanced computer analysis and data management techniques, including new procedures for information retrieval and archive maintenance. The technology we have developed for on-line data management and data analysis could provide many of the building blocks for a system to satisfy the interactive requirements and archive management for a large number of users with divergent interests. Such a system could become much more than an improved archive management capability--it could develop into a major extension of the methods of scientific communication: In addition to retrieval and analysis, many of the informal procedures surrounding the communication of ideas and data could be incorporated explicitly into the system. Specifications for these



capabilities would be established by an assessment of the needs of behavioral scientists, policy analysts, and planners and by pilot studies on existing data archives.

A common requirement for each of these proposed developments is the need for a large-scale, time-shared computer system. With the three areas of development sharing a common and systematic base of operation, the potentials for mutual support among them would be materially enhanced.

As the discussion in the next section will demonstrate, the support offered by powerful inductive analysis tools could reduce the constraints on the experimental design and data collection in simulation and gaming research; in turn, the research data collected could serve as a generating source for guiding the on-going development of the data analysis system. Laboratory research would also be supported by a data resource system having ready-made, on-line data banks available for participants in real-world simulations; in turn, the information demands of decision makers in realistic experimental contexts could help delineate the operational requirements for the form, content, and service demands of the data resources system. Finally, and perhaps most obviously, the data analysis system would augment the data archive management functions with tools for analysis and evaluation. These do not, of course, exhaust the possibilities of mutual support; others, not now identified, will undoubtedly emerge from the demands of use where the common base of operation makes such demands reasonable.

In the most practical terms, a pivotal consideration in the projected success of a research center should be its actual and perceived utility to the behavioral science community. The more closely the support developments are related by demonstrable usefulness to on-going research, the greater the likelihood that the center will be genuinely useful and used. This principle, which seems so obvious, is often lost in the process of formulating and designing research support systems. This happens in part because system users and system producers generally represent distinct groups in terms of interest and/or experience; as a consequence, highly

technical and readily identifiable demands of computer and software implementation tend to take precedence over the less compelling needs of application. A practical and direct remedy for this is to make sure that the developers of the requirements of the research center are also among the major users. This strategy is incorporated into the center.

The initial specifications of requirements were derived largely from our past project efforts to extend behavioral research to policy relevant areas through the use of computer capabilities. Since the technological, methodological, and data analysis specifications have all grown directly out of the practically perceived needs of a substantive research program, there is a high guarantee of utility that could not otherwise be derived. For on-going developments, this close operational association between in-house, substantive research projects and resource support programs is to be continued. For the area of data resource utilization, where the requirements are less well defined, we plan to rely more heavily upon those associations, groups, and individuals who constitute the major users of data resource systems.

PROGRESS ON PROJECT: 1 JULY 1969 THROUGH 30 JUNE 1971

Background and Summary

Progress during the first twelve months of the project was severely curtailed by protracted contractual negotiations; a definitive contract was not implemented until the last week of the first year. Establishment of the CCBS laboratory was delayed pending resolution of administrative and technical questions raised by the Office of the Vice President, Business and Finance, University of California. An extensive technical and administrative review on the selection of the central computer configuration was not completed until mid-December 1969. Following this review, negotiations on the final contract had to be reinitiated in order to reflect the University's acceptance of a change in the central computer configuration (preliminary negotiations, following the terms of the letter contract, were based on the U.C.L.A. IBM 360/91). A revised proposal audit by the local representative of the Government Contracts Audit Agency was submitted to the contract monitor in early January 1970. Preliminary negotiations between Rome Air Development Center (Contract monitor) and the Office of Extramural Support at U.C.L.A. (representing the University) were completed in March 1970. A finalized contract was established the last week of June 1970.

In sum, the project operated for the entire first year without the enablement of a finalized contract, and without authorization to acquire the central computing system and its major components of hardware and software support. Additionally, during the first half of the year nearly all planning and preliminary steps toward implementation had to be deferred until the decision on the central computer configuration was resolved. In the

absence of enabling conditions--without definite selection of the central processing system and without contractual authority to purchase major equipment, to subcontract for software development, or to develop project staff--the proposed schedule of development for the first year was critically compromised.

By contrast, the project has progressed at an accelerated rate in the second year; as a result, we have been able to recoup a significant portion of the schedule slippage due to first year delays. Phase I of the computing system is essentially complete, both with respect to hardware configuration and operating system software. Phase II hardware and software design has been developed through a detailed formulation stage; we are ready to undertake steps for implementation. Two higher-order programming languages--JOVIAL and META--have been developed; META is now available for applications programming, and an operable version of JOVIAL will be available early in the next quarter. An interim version of the computer-based laboratory has been developed; these facilities are physically limited in terms of participant positions (only three positions as contrasted with twenty-four positions being developed in the permanent laboratory), but otherwise provide a prototypical context for experimentation. We have developed a programming system that provides rapid and easy laboratory implementation of experimental research designs. In data management and analysis, we have implemented (a restricted version of) TRACE, a system that essentially provides implicit programming capabilities in data analysis; and we have implemented a fully-interactive version of IDEA, a program that provides computer assistance in the task of inductive data analysis. In sum, the overall project development is still behind the schedule originally proposed, but considerably less so than might be expected with the first-year delays. More detailed progress is reported in the following areas:

Computer laboratory developments.

- .Specification and acquisition of computer system hardware.
- .Specification and acquisition of computing system software.
- .Laboratory facility design and implementation.

Data management and analysis systems developments.

- .TRACE--data management developments.
- .IDEA--inductive analysis developments.
- .Data resource management--archive developments.

Simulation research and methodology development.

- .Scenario topics, conceptual issues, and scenario developments.
- .Computer methodology developments.
- .All computer simulation modelling of international conflict.
- .Experimental and para-laboratory research studies of human behavior in situational conflict.

## Computer Laboratory Support System

### Background and Rationale

The overarching goal of the laboratory support system is to develop (and make available) capabilities for extending experimental behavioral research, particularly into areas of practical concern, through the use of on-line computer software and hardware support. Within this broadly defined objective, we will provide means for studying complex social-political situations with the tools developed for this laboratory setting.

The equipment of the laboratory system consists of a general purpose central computer, a communications-processing peripheral computer, and a number of general-purpose input/output devices. These basic capabilities are operationally augmented by other equipment configurations (TV monitoring, video and audio recording) that provide additional methodological options to the researcher. With these general-purpose capabilities, the whole range of functions necessary for experimentation--the presentation of problem situations; eliciting, umpiring, and processing of subject responses; generation, routing, and display of feedback information; general administrative functions of recording, updating, timing--can be performed. The general capabilities of the computer-based laboratory are also substantially and critically augmented by the parallel development of data analysis capabilities, specifically designed to cope with the character and volume of data that computer-based research produces, and by the data archive and management capabilities. There are many obvious advantages in having a general experimental vehicle with these computational and controlling powers. Some advantages are simple extrapolations of typical methods and procedures--performed with greater precision, accuracy, and speed. But of far greater importance are the increased capabilities permitting the investigator to develop new techniques and methods of research.

In discussing the physical facilities, computing capabilities, and electronic equipment as a "laboratory", there is no intent that it should be so narrowly conceived as to support only experimental research. In almost every regard there has been a conscious attempt to design a multi-faceted center that could support a broad range of intersecting research and educational activities--behavioral simulation, all-computer simulation, data management and retrieval, computer-aided theory development, and computer programming. Support for these various activities has been planned with explicit provision for the developmental as well as the research phases; in particular, the hardware and software configurations have been designed as much for the activities of program development--system programs, laboratory programs, data analysis programs, and modeling programs--as for their use in the data gathering phases of research.

#### Specification and Acquisition of Computing System Hardware

The substantive areas of research in the program are predicated on the development of a large-scale time-sharing system to support the proposed computer-based laboratory and data-management capabilities. Development of the computing system is an explicit and essential part of the project's responsibility.

#### Central System Computer

To satisfy central system needs, two options were described in the original project proposals: (1) sharing the IBM 360-91 at the Campus Computing Network at U.C.L.A., or (2) using a dedicated machine to be acquired through lease or purchase.

A decision was made in favor of an independent central processor rather than the use of a limited part of the U.C.L.A. computer. Specifications were drawn to satisfy CCBS requirements, an RFQ issued, and three bids received and evaluated. A purchase order was issued the final week of June 1970 to Digital Equipment Corporation (DEC) for a PDP-10/PDP-15 dual processor

computing system. Both processors interface to the PDP-10's 262,144 words of 36-bit, 1.8  $\mu$ sec. memory.

The PDP-15 component of the computing system is utilized primarily to support high-speed interaction with local user terminals. The system includes two special components developed according to CCBS operational specifications. These special components are in an interprocessor memory interface and a high-speed communications interface. The memory interface permits the PDP-15 to read from, write into, and execute instructions residing within PDP-10 core memory just as it would with PDP-15 memory. As a result, the two processors can both access common memory. An additional communication channel between the two processors is provided over each one's I/O bus, providing the means for mutual interrupt and passing of status information. Control of the common memory is retained in the PDP-10, which can establish protection bounds and relocation for the PDP-15. Since the special communications interface equipment on the PDP-15 references memory directly by means of a separate address register, buffer, and counter for each communication channel, high speed interaction is possible with minimal loading on either processor.

The purchase order of June 1970 covered all major components of the data processing system except for a high-speed printer and plotter. After competitive bidding, a high-speed printer/plotter was selected in April 1971 that would meet CCBS needs.

During the last half of fiscal year 1971 a study was undertaken to determine the best method for implementing a multiple virtual memory capability in the PDP-10 hardware. Such a capability is central to the TRACE data management system. As developed for the TRACE system, the virtual memory capability permits memory to be paged but does not require it. The CCBS concept also involves multiple concurrent virtual memories, each independently addressable by the same program. These differences reflect a fundamental divergence in philosophy and goals from other approaches that have been oriented toward a reduction in



system overhead by means of hardware paging of memory, from which a limited form of virtual memory results; the CCBS approach is directed at facilitating the design, development, and implementation of large and complex program systems that interact with massive amounts of variably-structured data. Whereas the other approaches tend to be concerned mainly with efficiency of program execution, the primary concern for CCBS is the efficiency of program development. In this sense, the CCBS concept of virtual memory is best viewed as falling in the area of operating systems. In prior development of TRACE at System Development Corporation, this concept was implemented by a software simulation of virtual memory hardware at an overhead cost approaching 500%. An overhead of this magnitude is acceptable while validating a design methodology, but it is intolerable in the projected CCBS operational environment. The need to reduce this overhead to a more acceptable level indicates the need for at least a partial hardware solution. By modifying the addressing logic of the PDP-10 processor so that the most frequent virtual memory access functions are performed by hardware, most of this overhead figure can be eliminated. Coupled with such a hardware change will be a revised timesharing monitor that supports this capability and an extended JOVIAL compiler that makes these concepts available to the programmer at the level of a higher-order programming language; taken together, these developments constitute a major portion of what has been referred to in the CCBS proposal as the Phase-II Operating System.

#### Communications Terminals

These were to be acquired on the basis of selection from vendor responses to CCBS specifications for softcopy terminals with high data transmission rates, large text display capacity, and graphics capability. The Computek Model 400/15 terminal was selected; issuance of a purchase order for 24 terminals was made in the first quarter of fiscal 1971; all terminals were delivered and operational by the fourth quarter of fiscal year 1971.

The Computek terminals represent a significant advance in state-of-the-art--high-speed, large-capacity, low-cost text/graphics terminals. Based on the Tektronix 611 storage tube, the terminals can write 51 lines of 80 columns of upper- and lower-case text (95 different characters) in less than six seconds. In addition they can display any number of graphic vectors with a 10-bit resolution in addressability. One important new feature, developed by Computek in response to CCBS's needs, is the first light-pen capability offered commercially on a remotable storage-tube display terminal.

#### Hard-copy Interaction Terminals

The desired features for hard-copy interaction terminals were established as the following: light-weight, quiet operation, at least 30 characters per second transmission, full ASCII character set output (94-95 printable characters), keyboard that permits entering all 128 ASCII codes, easy maintenance, high reliability, moderate cost. A number of manufacturer's equipment were examined to evaluate their suitability for use by CCBS. On the basis of competitive bidding, the Texas Instruments Model 720 was selected.

#### Specification and Acquisition of Computing System Software Requirements

Computer software support for the CCBS facility involves three major components: (1) Phase I operating system software, (2) Phase II operating system software, and (3) higher-order language software. Judgments and decisions about software were, of course, dependent upon, and subsequent to, hardware selections.

#### Operating System (Phase I)

The selection of the PDP-10/PDP-15 hardware configuration provided a basis for planning and implementing the operating system software. It was decided that Phase I capabilities could be

achieved without extensive revision to the operating system delivered by the manufacturer, and that these modifications could be accomplished without subcontracting, i.e., by staff programmers.

DEC supplies a timesharing operating system with the PDP-10 computer. The principal component of this system is the monitor program that provides access to the basic resources of the system for many concurrent users. In the CCBS system, this monitor provides for support of terminal interactions, disc and tape access, peripheral device access, scheduling of the multiple users, swapping between core and drum, core and drum management, and protection.

Monitor Revisions. Although the PDP-10 timesharing system has a heritage going back to the PDP-6 computer, it has a number of inadequacies for the support of CCBS activities. They fall primarily in the areas of (a) terminal interactions, (b) disc and tape access, (c) device assignment, and (d) core management.

Terminal Interactions: The DEC operating system was developed around Teletype terminals. Although it currently supports more-recently developed equipment, it assumes that all terminals produce only text output on the functional equivalent of a continuous scroll. The Computek terminals that CCBS selected produce both text and graphics on the functional equivalent of discrete pages. Because these "pages" all must share a common display surface, new techniques had to be developed that would interrupt output at the end of pages and permit the user to indicate when he is ready for the next page of output. These are now incorporated in the monitor. Support of graphics will be incorporated at the monitor level when the operating system for the PDP-15 is developed.

Disc and Tape Access: The DEC operating system evolved from an early orientation toward DECTapes and magnetic tapes as the only peripheral storage devices; the present system, in addition, permits public and private rotating storage. Apparently because of a desire to maintain both device-independence and upwards-compatibility in the new DEC systems, many features of the latest operating system have incorporated techniques and conventions that are appropriate for DECTapes but

otherwise are inappropriate. In some cases, techniques and conventions have remained unchanged although time-sharing technology has advanced considerably in these areas. DEC has made a major effort to improve this situation in the Series-5 monitor (released to CCBS in December 1970), but a number of changes were still required to meet CCBS needs. These changes provided for better protection of private, removable volumes of storage by applying to DECTapes and magnetic tapes some of the volume-labelling conventions available for disc packs and by extending these conventions.

Device Assignment: Another legacy from the early DEC operating systems is a particularly primitive mechanism for effecting the assignment of private devices (e.g., DECTapes, magnetic tapes, private disc pack drives) to individual programs. The technique still followed in the Series-5 monitor--where each user is responsible for requesting a physical device and for informing his program which device has been assigned--might be acceptable in an environment where the users are all in the computer area and are all experienced programmers, but it is hardly appropriate for an on-line laboratory where the users are both physically remote and naive. As a result, a resource-allocation function was added to the monitor that performs the device assignments for the user. With this feature, all references to the system's physical devices are made internal to the programs as references to logical devices after the program has requested assignment to it of some physical device to correspond to that logical device. All directions to the operator to mount or demount volumes on or from physical devices are generated automatically by the allocation function as results of appropriate program references to the logical devices. Consequently, there is no possibility of conflicting demands on system resources or incomplete or ambiguous messages requesting devices or volumes being sent to the operator by the users. These changes have been designed in concert with the modifications for labeled volumes.

Utilities Revisions. The manufacturer-supplied utility programs required extensive modification and augmentation in order to accommodate the unique operational environment posed by CCBS, and to provide the special tools required for the development of the extensive applications systems.

Terminal Support: The terminal support portion of the DEC monitor as delivered did not permit the user to enter the entire 95-character ASCII character set, having preempted the right brace (}) and the tilde (~) as interrupt characters. Both of these characters are required for the PDP-10 JOVIAL. A modification to the terminal support routine has been made to limit the interrupt function to the ASCII escape control-code, permitting the other characters to fill their normal roles. All of the DEC-supplied utility software that responded to the old interrupt characters have also been modified to accept the ASCII escape code and not respond to the right brace or tilde as control characters.

Text Editor: Two text editors are supplied with the DEC system: one is a line editor that is extremely primitive; the other is a context editor that is exceedingly complex and difficult to use. A powerful, yet simple and forgiving line-oriented context editor is an invaluable tool in the development of software systems, so a new editor has been developed, combining the best features of the DEC editors and the EDTXT context editor developed under ARPA support for the Q-32 timesharing system at System Development Corporation (SDC).

#### Operating System (Phase II)

In order to provide full operating capabilities required by CCBS, especially in the development of data management capabilities, extensive system-software development and modification is required. The general requirement for operating-system-level references to a virtual memory can best be accomplished with a hardware/software modification; the hardware design has been discussed above; the software modifications will be based on core management techniques currently being implemented.

Central to the development of the TRACE data management system is a virtual memory capability and a general-purpose core-management service designed around that capability. In previous development of a prototype TRACE on the Q-32 computer at SDC, both the virtual memory capability and the core management services were accomplished by a software routine called SMART (Supervisor for Management and Allocation of Reentrant Tasks) that operated as a user job under the timesharing monitor and, in turn, functioned

as a secondary operating system under whose control the TRACE system ran. Eventually, the virtual memory capability of SMART will be implemented by means of a hardware modification to the addressing logic of the PDP-10 processor, and the core management services will be incorporated within the timesharing monitor itself. By this means, we expect to accomplish a reduction in overhead for these functions that may reach a factor of fifty. These activities are not expected to start, however, until the beginning of fiscal year 1972. Until then, SMART is being adapted to the PDP-10.

Higher order languages. Available higher order languages were evaluated and considered inadequate for CCBS applications, especially in the areas of real-time control and data management. Two higher-order language developments were planned: JOVIAL and META.

JOVIAL. Almost all of the applications system programming is going to be written in JOVIAL, partly because most of this software is an extension of earlier programs written at SDC under ARPA sponsorship, partly because JOVIAL has been the most widely used higher-order programming language among CCBS staff members, and partly because the nature of the applications software makes other higher-order languages inappropriate. A contract was signed with Abacus Programming Company at the end of the first quarter of fiscal year 1971 to develop a JOVIAL compiler for the PDP-10 computer and the DEC operating system according to CCBS specifications. A usable product will be delivered by Abacus within ten months of the start of the contract, which will be early in the first quarter of fiscal year 1972. A thoroughly debugged and optimized compiler will be delivered in the third quarter of that year.

Two significant extensions are planned for JOVIAL, to start after the delivery of a usable compiler: the incorporation of the virtual memory concepts discussed previously and the implementation of a JOVIAL-level interactive debugger. The virtual memory features will be coordinated with both hardware and operating system modifications so as to provide the most appropriate notation for the user and to result in the most efficient implementation and execution. The JOVIAL debugger will also be coordinated with this effort so that those programs written with the JOVIAL notation can be debugged using the same notation.

META. The META compiler is an interpretive meta-compiler whose language facilitates the expression of syntax rules and transformations from one formal syntax to another. The TRACE compiler was written entirely in META, as was a translator that translates the META version of the TRACE compiler into JOVIAL so that it can be combined with the rest of the TRACE system into an executable program. META was developed at SDC under ARPA sponsorship. Although it was written in JOVIAL originally, an interim PDP-10 version of META has been written in assembly language for earlier availability. This effort started in the second quarter of fiscal year 1971 was completed in the fourth quarter and will be in operation in the first quarter of fiscal year 1972.

### Laboratory Facility Design

Development of laboratory facilities, aside from the computing system, involves three aspects: (1) housing of the computer and experimental facilities, (2) acquisition of laboratory equipment, and (3) production of software for laboratory applications.

#### Housing for the CCBS

Housing for the CCBS facilities will be developed on the U.C.L.A. campus. Plans for laboratory housing have undergone some modification in order to take advantage of an offer of better building facilities than those that were originally proposed. A floor of a new psychology building became available for CCBS use; feasibility studies substantiated the preliminary judgment that the laboratory requirements of CCBS could be realized within the space available on the third floor of the new Graduate Research Unit being built for the Psychology Department, and that the projected use of that space could be supported by the structure. This space provides better security, flexibility, and proximity to users than the space originally proposed. The cost associated with this better location was a delay in its availability for CCBS laboratory development.

Deferral of implementation necessitated development of interim laboratory facilities; these facilities provided a housing for the computer system hardware and also provided limited space to develop a prototype of the experimental laboratory. The prototype is limited to three participant positions but otherwise duplicates the experimental context of the permanent laboratory; this facility has proved extremely useful not only for validating laboratory design concepts, but also as a test-bed for laboratory software and for the initial experimental applications.

Development of the permanent laboratory is entering the final stage; pending final approvals, the necessary modifications to the third floor of the Graduate Research Unit will be undertaken. The modifications were necessitated by the building having been originally designed for general office and classroom space; the adaptation to our laboratory specifications--especially as regards computer housing, and the need for flexible and rapid spatial reconfiguration in the experimental area--required substantial modification of the facility. The permanent laboratory will be operational by the beginning of calendar year 1972.

#### Laboratory Equipment

In addition to the computer and interaction terminals, the laboratory requires other equipment (for monitoring, recording, stimulus presentation, and information exchange) in order to provide adequate facilities for a wide range of behavioral investigation. Specifications have been made for integrating a closed-circuit T.V. system, an audio monitoring/recording system, and a general control system into the computer-based laboratory. Acquisition of most laboratory equipment has been deferred to coincide with operation of the permanent laboratory.



Video System. The video system will consist of a closed circuit television camera and monitor in each of the 24 experimental cubicles, video recorders, mixers, patch panels, special effects generators, and other equipment. The video system will provide for remote visual observation of subjects, recording of subjects' gross behavior, and presentation of training and stimulus information.

Audio System. In addition to the audio channel of the video system, independent audio capabilities are required, consisting of a speaker in each experimental cubicle connected through a patch panel to a central public-address type system (possibly the audio channel of the video system could be used for this purpose) and a telephone that permits conversations among subjects to be monitored and recorded.

### Software for Laboratory Applications

If the potentials of the computer-based experimental laboratory are to be exploited profitably by the behavioral research community, provisions must be made to get the investigator into the laboratory. Past experience with our computer-based laboratories strongly suggests that although investigators generally perceive the laboratory's potential, they are more strongly aware of obstacles to using it. First, the operation itself is not generally understood. Investigators have typically used computerized statistical services, but for the most part, they are not programmers and those who are, are generally not familiar with control systems. Second, the lead-time to concrete results seems inordinately long. Most behavioral investigators are accustomed to building their experiments in successive stages, with frequent opportunities for testing and modifying their procedures; by comparison, the projected elapsed times between the specification of an experiment and a computer-administered version tend to be fairly long. Third, the specification process is an unfamiliar procedure. Each experimental program requires specifications to cover all interactive contingencies. The art of producing such specifications is not easily assimilated, and is not worth learning for the infrequent user. Altogether,

these considerations represent a significant barrier to widespread use of computer-based laboratory resources. They can be overcome, however, by providing a means of effectively translating the investigator's requirements into operational programs.

A laboratory programming system is being developed to provide software support for researchers with little computer knowledge (Meeker, Shure, and Cooperband, 1971). It assists them in implementing their experimental and simulation requirements as easily and quickly as possible; it does so by structuring the interaction between the investigator and the programmer who is implementing the investigator's research design. The modes and forms of the interaction in the program have been defined; the programming system has been formulated as a five step process: (1) Gathering the experimental specifications, (2) producing an interim version of the experiment, (3) reviewing and revising the interim version, (4) producing the definitive version of the experiment, and (5) executing the definitized version (i.e. conducting the experiment). The formulation of the laboratory program itself is structured in terms of a presentation/action logic; presentations are further defined in terms of format/content, and actions are further defined in terms of designated responses and action consequences. These chained and defined procedures are related to experimental condition. This formalization of the experimentation process serves to guide the development of the laboratory program, but it is not used as the conceptual scheme for eliciting experimental design specifications from researchers--they do not think of experiments in these terms.

This program is now operable and is being field-tested in our interim laboratory facilities; this shake-down experience will provide us with a proven laboratory program when the permanent laboratory becomes operational. A paper describing the system, "An Implementation System for Designing a Computer-based Experiment" has been written for presentation at the ACM National Conference, August 1971.

## Data Management and Analysis

The increasing complexity and growth of data sources require new means for the researcher to access, retrieve, edit, explore, manipulate, and analyze large data bases. This need will be satisfied through the continued development of interactive, computer-based data analysis concepts and systems (e.g., TRACE and IDEA) to utilize their capacity for intensive and flexible scrutiny of critically defined portions of large data bases.

### TRACE

TRACE is essentially a general-purpose data-base management system built around a simple model of data acquisition and representation that permits multi-level associations to be maintained among variables of different etiologies; this data management system is utilized to supply data to a general-purpose manipulative function that is driven by the output of a special compiler that interprets processing commands supplied by an interactive user in a powerful command language. This same data management system is also utilized to incorporate the results of manipulations back into the data base, establishing the necessary associations with pre-existing data. A description of the system is provided in "TRACE-III: An Implicit Programming System for Inductive Data Analysis" (Cooperband, Moore, Meeker, and Shure, 1971), to be presented at the ACM National Conference, August 1971.

The TRACE system is composed of three major components:

A compiler that interacts with the user, translating his commands into a binary intermediate language that drives all the other components. This compiler is written in the META programming language; the META assembly-language version of the TRACE compiler is then translated to JOVIAL by another META program. Implementation of the compiler must await completion of the JOVIAL compiler.

A data-base management component that, under control of the intermediate language produced by the compiler, builds data bases, retrieves data from data bases,

organizes these data in an array-structured workspace for manipulation, and updates the data bases with derived data left in that array-structured workspace. This component is written in JOVIAL; its implementation must await completion of the JOVIAL compiler.

An interpretive, manipulative component that, under control of the intermediate language produced by the compiler, acts on the data in the array-structured workspace created by the data-base management component, producing summary information displays, or new variables. This component is written in JOVIAL; its implementation, also, must await completion of the JOVIAL compiler.

These components all operate under the control of a software virtual-memory simulation and storage management system:

The SMART memory management system. SMART is an acronym for Supervisor for Management and Allocation of Reentrant Tasks. It simulates the multiple-virtual-memory capability assumed by the rest of the TRACE system. SMART has to be tailored uniquely to each operating system and each hardware system. As a result, it is written in the system assembly language. The PDP-10 SMART program is now complete. Although built expressly to support the TRACE system, SMART is a general-purpose control system under which any appropriately-written software can operate.

When a virtual memory addressing capability is implemented in hardware, all of the supporting functions in SMART will be incorporated into the timesharing monitor. By then the JOVIAL compiler should also have been modified to take advantage of both the new hardware and new monitor capabilities. The TRACE programs will have been written so as to minimize the impact of a conversion from virtual memory software to virtual memory hardware support.

#### IDEA

The IDEA program offers an inductive aid to a researcher for discovering and summarizing potentially interesting data models in the form of restricted tree structures for a multivariate data base. It permits the investigator to collaborate with an open-ended library of programmed heuristics in the process of uncovering

and representing the structure of his data. The result of an IDEA analysis is a decision tree that graphically represents the rule to partition a set of observations.

IDEA operates on the values of a number of variables that represent measurements taken over a set of entities such as interviewees or experimental subjects. For a given IDEA analysis, one of the variables is considered dependent. The group observations associated with a particular entity define a point in space that has one dimension for each variable. IDEA enables the investigator to develop a decision tree that partitions this space into exhaustive, mutually exclusive regions.

The number of potential decision trees for any interesting set of data is too large to permit an exhaustive search for the best partitions; consequently, the routines that search for structures are heuristic. They seek out a subset of candidate variables for partition at each node of the tree. These promising partitions are then evaluated by means of heuristically chosen criteria for assessing the success with which a partition can explain the variation in the dependent variable. At each node, the program recommends which independent variable to use and how its values should be partitioned; the user retains the option to choose some other variable or a different set of partitions for the recommended variable. The same process that is used at the first step in the analysis, when the entire data base or a random sample thereof is considered, is also used for subsets at lower points in the tree. Termination decisions are based on arbitrary thresholds for desired quality of fit, sample size, and improvement in quality of fit.

A fully interactive version of IDEA is now available on the CCBS system; this version is written in FORTRAN IV; it incorporates the graphic display of tree generation when run from a Computek device. Ultimately, IDEA will be incorporated into the data analysis/management system in JOVIAL in a manner that will permit it to function with a TRACE data base; the present, stand-

alone version will be used to develop improved heuristics with special concern to assess and guard against Type I errors in the resulting analyses.

#### Data Resource Management - Archive Development

The task of effective utilization of archives must be considered within the context of the inductive data analysis methods described above. The capabilities of TRACE, when extended and integrated into a single system, can provide most of the user services required of a data resources system. In addition to the capabilities described, TRACE can solve many of the technical problems associated with data archive management. For instance, the problems of how to determine the appropriate level of aggregation of data to be entered into an archive and how to compose data stored at different levels of aggregation are resolved by TRACE's capability to handle data at any level of aggregation and maintain appropriate associations both within and between levels. Further, the problem of standardized formatting is largely resolved by permitting the user to use whatever format is appropriate for collecting his data and to describe this format when he enters that data into the archive. The problem of specification of information in a data base is greatly reduced by giving the user the ability to reference his data symbolically.

The primary area in which additional development must now take place is in providing these services concurrently to a large community of users and still guaranteeing rapid access to, and the security of, the common pool of data on which they all operate and to which they all contribute. These general capabilities have to be translated into specific system design requirements through an assessment of the needs of current archive users and potential users of the CCBS facilities and by pilot studies to evaluate methodological innovations. The design of such a system must provide the flexibility for rela-

tively direct extension and upgrading as existing demands change and new ones develop.

The work in data resource management has been confined largely to the software aspects of the problem. A review of the state of the art was undertaken as the initial step in program formulation. Current operational data management systems, such as ADMINS, DATA-TEXT, DATANAL and TROLL, etc., have been studied. These reviews have suggested extensions to TRACE III to improve its data manipulation for archive management; and operating systems are continually evaluated especially with regard to archive requirements for virtual memory software.

### Simulation Research and Methodology Development

Laboratory simulation exercises are being conducted at a number of centers for the study of international relations, for evaluation of political-military strategy for crises and long range planning, and for study of other allied topics. One of two divergent approaches are characteristically used in these gaming efforts. In policy-oriented gaming, where credibility and realism are emphasized, data are not systematically recorded and analyzed, methodologies employed are typically unevaluated, and experimental control is deemed unnecessary except for constraining player departures from realism or the gamer's intended focus. In research-oriented gaming, where theoretical and methodological issues are of primary concern, superficial representation of reality and the use of unskilled players have led to extensive criticism and charges of triviality. In either case, because these games are administered, played, and observed manually\*, they are severely limited in the amount and subtlety of monitoring and control, in the level of detail and volume of data that can be gathered, and in the role played by the analysis of these data. Furthermore, where the complexity of situations being studied does not readily yield to the control sought in the standard application of the laboratory experiment--a situation characteristic of almost all laboratory gaming--these limitations in data acquisition critically curtail the value of these exercises for evaluation or research purposes. Consequently, whether policy- or research-oriented, such games are unable to deal with a number of important questions, some of which are so fundamental as to bear on the validity of the games themselves.

After carefully reviewing this area, we have evolved a research plan that attempts to join the assets in both approaches and to eliminate a number of the limitations associated with each.

---

\* In almost all so-called man-machine exercises, the computer serves as little more than a rapid desk calculator rather than as an on-line tool to improve the data collection and dissemination processes.



We believe that the use of on-line computer techniques in such complex games might well allow for a significant upgrading in the value of simulation. In particular, an attempt is being made to realize jointly the objectives of the theory-oriented researcher, and the more stringent demands for credibility and relevance of the policy-oriented practitioner, through our newly-developed computer capabilities.

In our program of research, we continue efforts that are directed toward a number of related goals: 1) Determination and study of issues which are simultaneously important issues in U.S. foreign policy and which are amenable to theoretical and research analysis that may be applied in a simulation setting, 2) development of computer and associated simulation methodologies for laboratory exercises, 3) development of computer simulation submodels of international processes based on the theory and data generated in the laboratory simulation studies and from real world data bank studies, 4) experimental and para-laboratory studies of human behavior in situational conflict, and 5) incorporation of real world data and on-line data and management techniques to help specify variables and control activities in the simulation setting. Project activities have been undertaken and are described in all of the above-listed areas except under the last item.

#### Scenario Topics, Conceptual Issues, and Scenario Developments

Proposed and developed simulation scenarios will continue to focus on some of the central issues of American foreign policy today--the factors influencing the degree, form and effectiveness of US-USSR involvement in local conflict.

A key problem of the United States foreign policy in the next decade will be the extent to which the United States can, in future crises, take actions that are commensurate with its conventional and nuclear power, its economic strength, its scientific and technological status, and its interests in the outcome of the

crisis. We are concerned with studying the factors which permit or constrain the United States and the Soviet Union from taking action in a set of representative crisis situations.

While pursuing the detailed development of particular scenarios, we are attempting to set forth a conceptual framework that raises questions about the dynamics of great power involvement. Most particularly we are concerned with the dynamics of confrontation and commitment processes in these circumstances. The evolving framework and hypotheses of interest are being used to shape scenarios and the simulation format as much as possible without compromising their policy-validity and their utility for policy analysis.

#### Confrontation Theory: A Theoretical Framework

In exploring the field of deterrence theory as it relates to U.S. involved crises in the third-world area, we began by reviewing case studies of what has happened in earlier crises (Korea, Quemoy, Vietnam). This led us to the formulation of the following general questions designed to help us explore the conditions of successful and unsuccessful deterrence:

Explanatory questions. (1) Why do deterrence successes succeed? And if we can develop the typology of deterrence failures further, (2) How do types of deterrence differ with respect to relevant independent variables, especially commitment?

Diagnostic questions. (3) How do defenders who correctly judge that deterrence is about to fail do so? (4) How do defenders who correctly diagnose the incentive structure of the attacker do so? (5) Would an analytical forecasting or a "single best guess" approach give the defender a better chance of guessing that deterrence is about to fail?

Prescriptive questions. (6) What are the action implications of different diagnoses of imminent deterrence failure? (7) What are the best reinforcing tactics to use if it appears that deterrence is about to fail? (8) What is the relative value of threat as against assurances, payment, or compensation?

Attempts to answer these three kinds of questions led to the development of the following new conceptualization of "Confrontation Theory: Introduction" by Prof. David Wilkinson and other members of the simulation project staff.

In summary, confrontation theory includes initiation theory (accounting for an Act -- or its omission), response theory (explaining a Counteract -- or a failure to Counteract), and outcome theory (explaining the result of a confrontation).

Deterrence is an attempt to avoid confrontation. Confrontation occurs when deterrence fails (or partly fails). Three aspects of confrontation are of special interest: the violation of deterrence by the initiator (Act) (since initiation of an Act represents a deterrence failure, initiation theory is a theory of deterrence success and failure); the reply by the responder (Counteract) (response theory is a theory of deterrence failure, "compellence", and the restoration of deterrence); and the outcome (gain and loss to each party). It is these three aspects that a theory of confrontation must seek to understand, explain and show how to control.

Confrontation is a process that may contain many interactions, in which each actor is alternately initiator and responder; this process may be regarded as a series of rounds, and each round studied in itself; or a process may be regarded as a single round, and studied as such.

Real confrontations often enlist many actors; two usually predominate, however, whether these be two major powers or two blocs. It is therefore a reasonable simplification to study "two-person confrontation"; and this theory will do so.

This paper starts from the assumption that the hypothesis-building stage of theoretical work requires the collection of a comprehensive set of variables. A total set of some 117 variables (plus their perceptual variants, numbering about 120) is employed to account for Act, Counteract and Outcome.

This set of variables is at least close to comprehensive. It has, however, its limitations. It is uncomfortably large; no weightings of most and least relevant are provided; which variables are nearly "independent", which are likely to be "intervening", is not indicated; variables with actual causal impact are not distinguished from those which are merely symptomatic of causes; overlapping variables have not been rigorously excised. These objections require both reflection and experiment for their satisfactory resolution.

At this stage, the variable-lists and schemata constitute a bare theoretical framework to help structure thinking and shape planning for policy games, laboratory experiments and simulations, by showing the variables from among which choices should be made when one zeros in on a particular investigation. The theory-builder should treat the lists and schemata as possible sources of independent variables from which those who intend to do an experimental analysis of confrontation may select many subsets, each answering to different specifications to vary and test. The policy analyst may want to treat the various schemata as checklists which will aid him in making a comprehensive analysis of a situation. Similarly, the investigator of a historical case and the observer of a policy game or simulation exercise may use the schemata as guides to significant aspects of any confrontation that ought not to be overlooked.

A schema for "Initiation Theory" has been developed that may

be used by observers or by the responder as an aid in predicting<sup>\*</sup> whether or not deterrence will fail and the initiator will Act. It might also be used by the initiator to calculate<sup>\*\*</sup> whether or not he ought to act. Similarly, the "Initiation Theory Schemata" may be used (on the assumption that an Act will be undertaken) by observers and responders, to predict what Act from among A (a set of possible Acts) will occur; by initiators, to calculate which Act should be chosen from among set A.

"Response Theory" may be used: by initiators and observers, to predict the chance and the likely type of response to a particular Act; by responders, to calculate the desirability of any Counteract, and the most desirable Counteract.

"Outcome Theory" may be used by initiators, responders and observers to predict the value of the outcome of an Act-Counteract pair or sequence (a confrontation) to the initiator and responder. It may also, in consequence, be employed by initiators to calculate the desirability of starting any such engagement, and by responders to calculate the desirability of provoking or accepting an engagement, or of seeking to avoid it by concessions, diversions and appeals to third parties.

These schemata may be useful to an actor who wishes to deter an Act or a Counteract, but equally useful to his opponent who desires to escape deterrence. The schemata contain the variables that might be manipulated by an actor in order to increase its own general propensity to Act or to Counteract; or to decrease

---

<sup>\*</sup> i.e., as an aid in their own predictive thinking. An able and informed analyst is assumed for the usefulness of the schemata. At the present time, they do not "predict" or "calculate", the analyst does; such an expression as "may be used to calculate" carries this word of caution as an implicit footnote.

<sup>\*\*</sup> But some variables useful in predicting may be of no use in calculating, because they influence a side's propensity to act directly rather than through their appeal to the reasoning processes of the leaders.

that of an opponent<sup>\*</sup>; or to increase its general chances of success in a confrontation relationship<sup>\*\*</sup>. The last three sections of the paper ("Preventing Initiation", "Preventing Response", and "Influencing Outcomes") suggest the subsets of variables that actors are most likely to be able to manipulate in order to suppress Acts, suppress Counteracts, and improve chances of success in confrontation.

### The Role of Commitment Processes in Defining Foreign Policy

The thrust of this effort has been toward the development of a conceptual framework for describing and explaining changes in military "commitments" as these are exhibited in data from the simulation runs. Beginning with the data obtained from the 1973 Mid-East exercises (see below), we have focused on the significance of commitments in the relationship between the principal belligerents, Israel and Egypt and their patron superpowers, USA and USSR. In particular, we were interested in the effects of the acquisition of nuclear weapons by Israel on these commitments. We have sought to determine the nature, strength and communication of commitments by the superpowers to the smaller powers; i.e., how they differ in terms of the following dimensions: explicitness and formality of declared commitments, strength of actual commitments (as perceived by the superpower patron, by its local ally, by the latter's local adversary, and by the other superpower, the interests underlying the commitment and the motives behind the particular

---

\* There is no reason why the same variables otherwise handled could not be used by a state to increase its own self-restraint (or enfeeble itself), to provoke an opponent, or to arouse or restrain an ally or third state.

\*\* All these uses are available, of course, only to the extent that the schemata are correct and comprehensive in the variables and hypotheses they state. The effects of errors and omissions in the schemata are as yet unknown.

communication of the commitment); and the symmetry/asymmetry in the respective superpower commitments.

Translating these concerns into more specific questions: To what extent, for example, do the major-minor power partners agree or differ in their understanding of the nature and strength of the commitment? Are there any misreadings of degree or kind of superpower commitments by adversaries as a result of implicitness of commitments? How does Israel's acquisition (in the game) of a nuclear capability change the nature, strength and communication of these commitments?

In attempting to answer these types of questions we have developed and administered scales and associated structured interviews with game participants and other interviewees. The scales aimed at determining the strength or willingness of the superpowers to honor defensive commitments against threats to their local allies.

The most recent work has temporarily shifted its focus away from these empirical pursuits to concentrate on a theoretical framework for studying the behavior associated with military "commitments". This, in turn, we hope will permit a more adequate evaluation of the data from the simulation runs.

For our theoretical purposes, a "military commitment" has been defined as intended and expected military collaboration in the event of certain contingencies. The essence of a "commitment" is that it constitutes a prior attachment to a certain course of action and consequently an intended (by the committor) and expected (by other actor) limitation on one's future freedom of action given the occurrence of certain events. There are three principal properties of commitment thus defined: 1) The scope of contingencies which would provide the stimulus or casus foederis for collaboration; 2) scope of the intended and expected collaboration; and 3) how these intentions are com-

municated and manifested (i.e. the degree or manifestation of one's "commitment" to collaborate given certain contingencies).

As used here, a military "commitment" involves at least three actor: a committor (A), the potential recipient of the commitment (B), and a third actor (C) whose conflict with either A and B or B alone constitutes a necessary condition for a potential commitment to military collaboration by A to B.

"Commitments" are viewed as instruments or means for influencing the behavior of other states in preferred directions. Positing influence as the purpose of "commitments" provides a perspective for identifying the relevant perceptions and calculations which underlie changes in military "commitments".

Interest in the effects of the acquisition of nuclear weapons on the above properties of "commitments" has been the main impetus to our study of "commitments". However, whatever effect this or other independent variables may have on "commitment" properties is mediated, of course, through the perceptions and calculations of the actors. Thus it is necessary to determine what effect the acquisition of an independent nuclear capability has on such perceptual variables as: A's prediction of B's and C's behavior in a given situation in the absence of the influence attempt; A's preference regarding B's and C's behavior; A's perception of the effectiveness of its influence base (i.e. the base values which constitute the condition for the attempt at the influence in question); A's evaluation of the relative utility (i.e. cost and benefits) of one "commitment" policy versus another or none at all; A's perception of the probability of the desired outcome or of the "weight" of its influence.

It is expected that any change in the values of these variables wrought by nuclear proliferation will in turn explain change in the properties of "commitment" identified above. The relevance of the conceptual framework above to the study of the effects



of nuclear proliferation on super power "commitment" can be clarified in the following way.

The acquisition of nuclear weapons by a state tremendously increases the destructiveness of its military capability. Whether or not this capability -- if used -- can affect the strategic balance between the super powers or simply a local balance, its use or potential use has definite implications for the system of international relations as it has evolved in the postwar period. These implications concern the continuance of the moderation and relative insulation of crises which has been due principally to (1) the restraint in the use of force exercised by the super powers and other current nuclear states toward one another, and (2) super power control over -- or the insulation of the effects of -- the more dangerous policies or conflicts of third actors.

This restraint toward one another and control or insulation of certain policies and conflicts of third actors can be analyzed in terms of the influence perspective and perceptual variables above. Without elaborating particular hypotheses, it is hypothesized that the proliferation of nuclear capabilities to more and more states will affect such variables as the super powers' predictions and preferences regarding the behavior of third actors and the behavior of one another to these third actors, their evaluation of their relative power to influence behavior in preferred directions as well as the relative utility of one means of influence over another.

For example, the acquisition by Israel of a nuclear capability may change the United States prediction of its behavior in the event of certain contingencies. The U.S. may, for instance, predict that Israel will use its nuclear weapons against an Arab threat somewhat below the threshold when national survival is jeopardized. It may prefer the Israelis not to use the weapons for a variety of reasons. In attempting to influence

Israeli behavior in the preferred direction, the U.S. will have to consider what base values it possesses for exercising influence over this Israeli decision, the probability of influencing the decision and the utility of various "commitment" strategies in doing so. Thus it is changes in these variables which it is expected will in turn explain changes in properties of "commitment" identified above.

It is anticipated this theoretical framework paper will be completed early in the next reporting period.

#### A Book on Scenario Design and Construction for International Relations Simulation Exercises

Although simulation games are finding wider usage (in universities and military colleges, as well as in military exercises), practically nothing has been written on how to prepare good scenarios, nor have any systematic procedures been developed to assist the scenario designer in organizing information, materials and concepts. Scenario design remains an art in which only few practitioners achieve products of high quality. As a consequence, most scenarios are designed on a hit-or-miss basis and are excessively costly; the implications for playability, representativeness, and relevance to theory and policy concerns are left to intuitive decision.

The purpose of the planned book will be to provide general and specific guidance on scenario development for study of international crises so as to contribute to an improved quality and economy of gaming. The book also will serve as a manual on how to conduct simulations, of procedures, record keeping, control problems, role playing, debriefing, etc.

During the first six months of the project, we have attempted to concentrate on obtaining a clear understanding of the various goals of the book, as they relate to the needs of different audiences; on translating this understanding into a working

plan for the book; on producing and critiquing substantive outlines of the main sections and chapters, and on beginning the drafting of key chapters. During the course of our discussions, we have been led to place greater emphasis on the value of constructing a simulation exercise as an important teaching and learning device. In order to construct a simulation, the student and designer must go through a detailed and exhaustive series of steps which require that he make very explicit assumptions about the nature of the international system. He must translate these assumptions into the construction of an alternative world description, and a crisis scenario, in ways that are logical and internally consistent. He must clearly sort out the presumed role of the many variables he has identified, and he must be clear about the purposes and expectations he is associating with the exercise he is creating. This is precisely the intellectual process the authors of the book have found themselves immersed in, and it became increasingly clear as work progressed that readers of the book should be given a similar opportunity to go through this process, since it is of great value as an aid to clear thinking about one's own views of the international relations process that enter into the scenario construction. Accordingly, many of the chapters in the book will go well beyond their original conceptual structure. In addition to providing instructions to the reader on how to proceed in the construction of a simulation exercise, and examples of exercise materials, we will attempt to explicate the step-by-step intellectual process which led us to make certain choices and assumptions, and we will provide the framework for the reader to move through a similar process on his own. We anticipate that this will require substantially more effort than we had originally assumed, but we believe it will be well worth it if our expectations are borne out about the enhancement of the book's value that will be possible through this approach.

The book at present is divided into four main sections. An introductory section will deal with the purpose of simulation

exercises, and their role in the study of international relations. Another section will address the problem of how to create alternative world descriptions from a set of variables based on theoretical and policy considerations. These variables will require specification at a number of levels for defining the critical components of a variety of interesting future worlds (tentatively set in the 1980 period). These module descriptions will be prepared in sufficient detail along with rules for their combination so that various world backgrounds, foregrounds, crises and national actors may be configured. Another section will deal with scenario construction and examples describing and illustrating how it will be possible for each investigator to construct, from a wide variety of simulation possibilities, scenarios that are tailored to his needs. Characterizations of a variety of national regime types will further increase the uniqueness of focus that may be achieved. A final section will deal with the problems of setting up and playing an international relations game. We are also studying the feasibility of going through one complete run of the simulation exercise described in the book as an example, and reporting in a final chapter on the results of the run.

Three draft chapters have been completed and are being revised: Two on scenarios, and one on alternative worlds. A draft chapter on alternative regime types is in final preparation, and the material for chapters in the introductory section has been outlined in detail, with a draft chapter expected early in the next reporting period.

#### A 1976 Mid-East Scenario for a One-Team Simulation Exercise

This scenario explores deterrence and commitment considerations that would motivate an American decision to give large-scale direct military assistance to Israel under conditions of increasing levels of Arab-Soviet endangerment of Israel.

The game is organized around a pre-game scenario setting the stage for future developments in the Middle East. In incorporates a bias; i.e., it assumes that the steps taken by the Soviet Union in the Middle East since 1955 are following a pattern toward the exercise of greater influence in the area. It assumes that the Soviet Union wants to reopen the Suez Canal to facilitate its shipping, and is linking up its policy activities in this area with those being undertaken in the Indian Ocean area. The game will require large-scale direct Soviet military assistance to the Arab nations for the announced purpose of forcing Israel back to her pre-1967 boundaries and implementing the UN resolutions of November 22, 1967, which were supported by the United States. The essentials of this scenario were developed in the New York Times for June 5 and June 28, 1970, by C. L. Sulzberger and George Ball.

The game scenario introduces at reasonable intervals a series of Arab-Soviet actions which progressively threaten Israel's security and, ultimately, its survival as a state. Control presents to the U.S. team at each interval a description of the situation created by a new Arab-Soviet action. An Israeli request for a specific amount of U.S. military assistance is then made, and the U.S. team is required to decide on a reply from a range of alternatives, to give an explanation and rationale for the decision, and to make an estimate of the effects that their decision will have, i.e., what the next Arab-Soviet action will probably be. The game scenario is designed to progressively sharpen a conflict in goals for the U.S. team -- on the one hand there is concern for the viability of Israel as a nation, and on the other the concern not to become involved in overt hostilities with the Soviets in the Middle East. The U.S. team, then, will presumably be faced with a dilemma -- two mutually exclusive strategies, each with potentially good and bad consequences. The scenario is designed to examine the behavior of U.S. players who cannot escape between the horns of this dilemma (i.e., finding an easy "solution"); but it does not prevent players

from temporizing or trying to compromise. The question of substantive interest, then is whether players will accept the consequences of one of the pure strategies (commitment or non-involvement) or be drawn to compromise alternatives (some level of partial commitment with attendant partial involvement) which are psychologically attractive, but may be strategically poor in a series of escalation moves.

Pilot runs of the game have been conducted in a manual semi-computer mode; these runs provided reassurance that the game was "playable"; the next step, programming the simulation for computer administration, has been completed with a revised version of the pre-game scenario and game moves.

#### Content Analysis of Completed Mid-East 1973 Simulation Exercises

In our earlier simulation series, we focused on achieving a laboratory simulation that avoids or minimizes the use of procedures that trivialize or simplify issues so that the simulation activities and results would not be viewed as superficial by policy experts. With this goal, a series of four manual simulation exercises were run using a Mid-East crisis scenario that explored the political-military implication of nuclear acquisition by Israel. The four runs differed primarily in terms of the levels of sophistication of the participants. In these runs, four teams (three members each) represented Egypt, Israel, the United States and the Soviet Union. Papers reported on similarities and differences in team behavior and content for the four runs and for similar and different nation groups.

During the most recent reporting period, work has been completed on a parallel computer content analysis of the team position papers and game moves for all of the exercises. In addition to the previously analyzed simulation record for the RAND/UCLA exercise and a team of area specialists from the Department of State, the data obtained from graduate and undergraduate runs

were also analyzed and aggregated with the former data. For the four simulation runs, an approximate total of 30,000 words were encoded, half of which were manually tagged (in distinct thematic units of actor-action-target) and used in the program output.

The data generated in our simulation exercises for our content analysis included team communiques, public "messages" to international "press services", "speeches" in the United Nations and national team position papers (an evaluation of the situation of related objectives and contingencies prepared at the beginning of each session).

The primary research tool used in these investigations is the General Inquirer computer program for content analysis, as modified by Oli Holsti of Stanford University. At its core, the Stanford General Inquirer utilizes a 3700 word dictionary -- a listing and "definition" of the most frequently occurring words generally found in political documents. Each word in the dictionary is scaled along three basic semantic dimensions -- evaluative (good-bad), potency (weak-strong) and activity (active-passive). The use of this particular dictionary reflects the basic assumption that when decision makers perceive any object of meaning, including themselves, the most relevant discriminations made are based on these three dimensions.

The output of the Stanford General Inquirer allows an investigator to draw conclusions regarding a nation's perception of the qualities and performance of any national actor and of a nation's actions toward any other particular national actor (included in the set of documents under analysis). Thus, one may examine how national actors (perceivers) evaluate any other nation -- along the three semantic differentials.

Previously analyzed findings presented in the last technical report were compared with data generated in the two student exercises. A final report on these runs is in preparation and

should be completed at approximately the end of this reporting period. The results not only appear to be of substantive interest but they allow us to compare the results of the content analysis program with the results of other analyses, and to determine its utility for policy/simulation generated data.

#### Computer Methodology Developments

The most important development in this area is that associated with the computer-based laboratory implementation system (LIS) reported on pages 19-20 of this report. Three other significant developments are associated with the work on the two Mid-East exercises described in the preceding pages.

#### One-Team Simulation Exercises

The purpose in developing a one-team simulation is to create an international relations game which requires only limited personnel for administration, and affords greater control for research purposes. It is an effort to provide a simulation format that offers greater efficiency, control, and standardization; this is the rationale for reducing the response roles to a single team, the U.S., while all other nation roles in the game are simulated. Not only can a number of U.S. teams be run simultaneously, but the physical presence of a number of teams adds to the credibility that these other teams are being played "live" rather than being simulated by the experimenter.

The computer developments for this activity are being implemented in relations to the simulation exercise described on pages 38-40. With the completion of the laboratory facility, laboratory runs will be initiated using this computer-administered format.



### Interactive Automatic Theme Encoding of Messages and Documents for Content Analysis

Progress in the area of automated language analysis has continued in recent years, with major attention turned away from such unmanageable tasks as fully automatic high quality language translation to the development of more sophisticated syntactic and lexical techniques for other applications. These techniques may be employed to meet the need for more efficient analysis of verbal interaction data that are collected in experimental gaming, social interaction, and simulation studies. For the most part, such data are either superficially analyzed by such computer programs as the General Inquirer, or great sums of time and money are spent in having them more deeply analyzed by trained coders. It should be noted that the thematic analysis required for the computerized content analysis previously described was all done manually.

Operational translation-oriented parsing systems (parsing program, grammar, and dictionary) such as the Harvard Syntactic Analyzer and RAND's PARSE have been shown to correctly analyze about 50% of the sentences encountered in ordinary newspaper text; the remainder are multiply parsed (about 30%), not parsed at all (about 15%), or parsed incorrectly (about 5%). There is good reason to think that for the task of theme encoding the corresponding performance figures can be improved significantly, making such a system a practically useful tool in message and document analysis.

The problems of automatic parsing for theme encoding can be reduced to tractable proportions by some modification of the following approaches: 1) The scope of the parsing problem is analyzed in terms of the character of the data to be analyzed. The approach of the Stanford group is to use a simple grammar, and to use a simple algorithm for parsing. This is simpler than grammar analysis and translation. 2) The language of the message to be analyzed is constrained to accommodate the theme encoding task.

composer may be required either (a) to use a habitable English subset, or (b) to provide ancillary cues with messages in unrestricted English. Either alternative, if used, would be implemented with interactive training and refresher aids.

3) Interactive man/machine resolution of theme encoding problems can be introduced at several points in the evolving system. The computer will generate aid requests diagnostic of such a problem to a human analyst who will then supply additional data or decisions as required.

The grammatical requirements of automated thematic analysis, the consequent extent and kinds of language restrictions on message composers, and the tactics of man/machine integration in overall system design will be the subject of investigation to determine a configuration that least restricts and interrupts the message composer while achieving acceptable levels of performance in theme encoding.

This effort has begun with the development of a thematic parser whose performance will provide estimates for the determination of initial system requirements. The development of interactive and fully-automatic system components will proceed jointly. To the greatest extent possible, especially in the area of dictionary development, existing programs and data will be adapted to our purposes.

A general document describing the grammar-parser has been written by Gary Martins.

Presented at the tests of the Stanford General Intelligence Test. The test is designed to measure the ability to understand and use language. It is a multiple choice test with 100 items. The test is designed to measure the ability to understand and use language. It is a multiple choice test with 100 items. The test is designed to measure the ability to understand and use language. It is a multiple choice test with 100 items.

Attempts to establish validity are of two kinds. Construct (direct) validity is afforded by determining how well estimates using the instrument compare with alternative means of measuring the same phenomena. Thus a new IQ test might be compared with other measures or teachers' ratings of intelligence. Predictive validity attempts to assess an instrument by inferring its validity indirectly by examining its hypothesized relationships with other variables. A good measure will normally exhibit both forms of validity. It is thus surprising that although the Stanford General Inquirer has been extensively used in the analysis of political documents, there is not a single published report that indicates whether the inferences based on the three semantic differential scales used to describe national actors and their behavior conforms to similar characterizations obtained by other means. Instead, validity of these scales has been inferred indirectly from hypothesized relationships of the semantic differential categories to other variables. Since reported relationships are not impressively high nor uniformly obtained, there is an obvious need for some simple, direct assessments of validity of the Stanford General Inquirer. A series of simple experimental tests are planned to get at the validity of the techniques by systematically exposing errors which may occur at various stages in the content analysis procedures.

Initially, global assessment of validity will be made. Subjects will be presented with paper-and-pencil descriptions of situations involving a number of nations in well-defined conflicts or crises. Nation descriptions will be systematically differentiated in terms of attributes and behavior that would presumably lead to differential characterization along the evaluative, potency and activity dimensions. Subjects will then be asked to assume the roles of statesmen and/or advisors. They will be asked to make decisions about the behavior of the different nations and to compose a summary report of their decisions. The validity of the Stanford General Inquirer will be assessed by determining how accurately the Stanford General Inquirer will be able to reconstruct actor behavior from the

characterizations consistent with the specific information sets provided subjects. Beyond this general comparison the analysis will also attempt to determine whether the content analysis is done equally well for the three different scales; for actor, action and target units and whether different kinds of messages will be better or poorer vehicles for assessing scale information. Still at a general level, but viewing the messages from the standpoint of the recipient or policy analyst, to what extent will "natural" readings of the messages be consistent with the set of implications drawn forth by the computer analysis. To be sure, these are basic, general questions, but there is no information available of even this elementary kind.

At a more analytical level, to what extent does the semantic differential signification of a given sign depend on linguistic context? Are there general contextual determinants that can be identified, corrected, weighted, ignored? Are there more useful or appropriate grammatical parsings?

The potential questions are, of course, endless and a strategy of evaluation must be designed that is both economical and which moves rapidly to detect the major contributions to validity and error variance.

The analyses are still at the planning stage, but it is quite clear that they can be undertaken with minimal cost and effort. At the same time it is expected they would serve two major purposes of considerable importance: 1) The results would provide a much needed and long-overdue direct assessment of the validity of the content analysis procedures, and 2) the approach would initiate a more differentiated response to the detection and analysis of the various stages in content analysis at which validity is lost. The identification of these points in the analysis process where validity is lost would also provide specific requirements for the proceeding project on computer interactive theme encoding of verbal documents.

### Sequential Coding: A Suggested Modification to the Stanford Syntactic Codes

As a by-product of the two preceding efforts, an improved method for content coding has been conceptualized which utilizes interactions of the three individual Stanford codes (agent, action, target) together with operators (modifiers) to form sequences of codes. This method affords a more precise characterization of content relationships between sentence constituents than is possible with the use of the Stanford individual codes. That is to say, the sequential coding is closer to the natural reading of sentence content than that permitted by the Stanford coding.

The sequential coding system is based on a very simple grammatical structure using only three grammatical categories: predicates, operators, and individual names. With minor exceptions, predicates are two-place relations, the first place corresponding to the coding category "agent", the second place corresponding to the coding category "target", and the predicate itself corresponding to the coding category "action"; predicates include all ordinary verbs and common nouns. Operators are of two kinds: logical operators, constituted by the logical connections and quantifiers together with their time, quality or type, purpose or cause, source, and destination; modality operators include all ordinary adverbs and adjectives. Individual names are names of individual objects of interest, such as nation names, descriptions of nations, cities, geographical regions, political regions, etc. By allowing predicates to enter into the first or second place of other predicates (i.e., to occur within other agents and targets), we are able to uniformly represent the content structure of a great variety of English sentences using only three grammatical categories, and to encode this structure in terms of the three codes (agent, target, and modality) codes plus the operators. A paper describing the method has been prepared by the author.

### All Computer Simulation Modelling of International Conflict

These projects, under the direction of Professor Robert North, are partially supported under subcontract at Stanford University at the suggestion of Dr. Davis Bobrow, former director of ARPA Behavioral Science.

#### An Anticipated Ceiling on U.S. Defense Spending, 1951-1969

The anticipated Gap model of arms race behavior was tested on the US/USSR yearly defense budget over 1951-1969. The model predicts that heads of governments decide changes in military spending programs in order to close perceived, anticipated gaps between their own and rival government future spending. It is based on models verbalized by heads of government of major powers over the last 100 years, including more recent statements by John F. Kennedy, Robert McNamara, Richard Nixon and Alexsy Kosygin. The model made inaccurate Soviet predictions but dramatically accurate yearly predictions of U.S. budgets over the full 19 years. A translation from the mathematical results back into a verbal model for the U.S. might read as follows: "Changes in levels of increases in defense spending result from larger differences between our anticipated spending (six months to a year from now) and a fixed ceiling figure of X billion dollars per year."

In previous tests, the anticipated gap studied was that between one's own spending and aggregate budget of rival powers. Predictions for the U.S., however, were found to be independent of Soviet budget fluctuation, yet U.S. predictions accounted for 80-85% of the variance in changes in the size of yearly budget increments (significant at the .005 level). Serial correlations were reported and these results were found to be stable over time. A similar model was tested on the U.S. war budget from 1949 to 1969, but with the Vietnam war removed.

### Lateral Pressure Model

A paper entitled, "Germany and Japan: A Comparative Application of Model of Expansion", was delivered at the Western Political Science Association Meeting, April 8-10, by R. Lagerstron and R. North. It reports how values of lateral pressures (calculated from one or more of the three proposed models) predicted significant fractions of the variance in rates of change of Foreign Trade and Investments for Germany (1892-1912) and for Japan (1915-1940). The Japanese behavior pattern was steadier through the two periods, using full Trade and Investments overseas to attempt to fill the need for raw materials and markets. The results suggest that Germany switched its mode from Trade to Investments in attempting to acquire control over markets and raw materials sources. This finding is in agreement with previous findings. Both countries, during these similar phases of their development, were displaying behavior which apparently can largely be accounted for by the lateral pressure model. Some reversals of algebraic signs, and the magnitudes of the coefficients have not been adequately studied.

In a graphical study, specialized capability emerged as a crucial variance -- as predicted -- that enabled the lateral pressure model to account for the German move on the Rhineland in 1936 (and later into Austria), but not in the years 1926, 1929, 1934, or 1935 when Resource Demands, as defined in the model, was equally as high as it was in 1936.

### Data Collection

Aggregate data were brought up to current times on many variables for major powers. This work forms the basis for all testing of the models and is therefore a crucial component that must parallel serious theory developments.

### Salience Measures

A thematic analysis (done by hand on an earlier subcontract from USC of German Reichstag speeches (1870-1914) was used to predict increases in various German policy-relevant action variables. We feel that such salience measures will give clues to switching of modes of external action (lateral pressure). Multiple regressions using seven indices predicted significant variance in Imports, Exports, Alliance Commitments, and number of Men under Arms (Army; not really an action variable). The high-speed computer programs for content analysis were used to produce frequency series of co-occurrences of words with negative or positive affect with reference to countries discussed in parliament. These rudimentary themes were tested for predictive power on various action variables. The coupling of these two kinds of variables with aggregate data on the capabilities and needs of the country gives us the opportunity to use all three kinds of data in one model, a powerful advantage. An early attempt at this has not been conclusive. A report covering the entire past year's effort has been prepared.

### Experimental and Para-laboratory Research Studies of Human Behavior in Situational Conflict

The simulation approach, because of its complexity, particularly needs to be closely interrelated at many levels with other techniques of investigation to clarify its findings, to serve as a direct source of hypotheses, and as a simple setting for developing and testing new methods. It is necessary, then, that the research program continue to range widely in its approaches to problems from paper-and-pencil situations to computer-based experimentation. While these studies are only a small part of the total effort, we believe it is particularly important to have two lines of investigation in support of the primary activities: 1) our earlier program of experimental studies in the new computer laboratory, and 2) SCENQUEST studies.



### Experiments in Bargaining and Negotiation Processes

These studies continue to investigate bargaining and conflict resolution behavior in conflict-of-interest situations where parties are mutually dependant in the pursuit of otherwise opposing goals. In such situations, the bargainers frequently employ tacit means of communication, proceeding primarily through actions and maneuvers rather than through direct exchange of explicit communiques; they are able to impede one another, and to inflict loss or harm on the other party; they are frequently unclear about the values and power of the other party. Under such conditions, which breed mutual distrust, how do negotiators succeed in mutually influencing one another to contain or resolve their conflict? What are the characteristics of the exchange of moves and signals that lead to unilateral advantages or successful joint resolution? Can the properties of the bargaining context, or characteristics of the parties in the conflict, be identified as critical influences on the resolution process?

While no new experimental studies are being undertaken until the laboratory is available, results of earlier studies continue to be analyzed and written up.

### SCENQUEST - A Scenario Questionnaire Technique for Studying In-process Phenomena in Conflict Resolution

Many in-process phenomena cannot be studied easily in simulation exercises because they occur rarely, or follow unique patterns of antecedent events, or require more extensive subjective analysis than can be easily obtained during the exercise. The SCENQUEST approach, based on a combination of standard techniques, affords the laboratory investigator a convenient, low-cost means of collecting data on a wide variety of situations that require control and standardization of antecedent events. An example of such a situation is a player's sudden shift to aggressive moves in a condition that had been stable and characterized by cooperation, and where no outside triggering event

could be detected.

In the SCENQUEST approach, the experimental subject is given a specific opening or ongoing situation or game. The synopsis is in dramatic, real-life terms or in bare-bone, analytical ones, and may concern situations as complex as those presented in simulation scenarios or as simple as those in a prisoner's dilemma experiment. The synopsis may give a summary history of the events and decisions made by both parties up to a given point. The subject reads the scenario from the point of view of one party in the situation; he is then asked to respond as if he were in the situation with the history as it is given and in the designated party's place. He then records his response on a questionnaire form. This procedure contrasts with role-playing where a person is asked to adopt another's attitudes, opinions, etc. The respondent here is situation-playing.

An ongoing SCENQUEST study explores a number of determinants of the perceived size of conflict at the opening phase of an experimental bargaining situation. Variables identified for analysis include size of stake in the bargaining, divisibility of issues into separable bargaining units, amount of opportunity for exchange of bargaining offers within a negotiation encounter, number of negotiation encounters, and degree of inequality of trial outcomes (relatively equal to vs. highly unequal potential division). Game materials, instructions and recording forms have been developed for these variations. A 2<sup>5</sup> experimental design explores the effects of these variables singly and in combination on a set of 57 dependent measures and 26 derived measures. These measures include assessment of the effects of the independent variables on earning goals, strategic and tactical planning, and other bargainer perceptions. The results appear to be usefully consistent in pointing out factors that contribute to a tactical, attentive orientation to negotiation versus a strategic orientation to the variety of

negotiation situations presented. During the past reporting period, data collection for 480 subjects has been completed and final analyses for these results are now underway. Some sample findings indicate the following:

1. Incentive Effects. The subjects global orientation toward the negotiation situation and his strategic decisions were significantly influenced by whether the subject anticipated bargaining for real versus imaginary money outcomes. When stakes were to be imaginary, the subject both characterized himself and the other bargainer as more competitive, and anticipated that he would bargain more competitively (with a lower perceived probability of realizing his earnings goal) than in real money conditions.

These and other findings on incentive will help us fill out the important differences in orientation that result from this variable and indicate that its effect on behavior is more complex than that suggested by a characterization of consequences that derive from a simple "more-or-less" incentive conception.

2. Unequal Trial Outcomes and Potential for Equalizing Overall Bargaining Outcomes. Where subjects believed they were to bargain for real money stakes, characterization of themselves and of their adversaries on semantic differential items differed significantly as a function of the variable "inequality of trial outcome". Where trial outcome differences would be large, subjects rated themselves and their adversary significantly lower on all five items associated with the evaluative factor -- i.e., as less trustworthy, less peaceful, less moral, less fair, and less generous -- than where relatively equal division of outcomes could be achieved through negotiation. Subjects also rated themselves higher on two of the dynamic items, more active and more unyielding, and on the strategic item, when trial outcome inequality was large than when it was small.

The number of trials (1 or 10) was important in determining whether inequality of trial outcome could be equalized. (Equality could be achieved in the ten-trial condition if subjects agreed to "take turns" in opting for the larger outcome; of course, this was not possible in the one-trial condition.) Subjects characterized themselves as more competitive in the one-trial than in the ten-trial conditions when playing for real money.

In contrast to these findings, it is of interest that in response to questions regarding tactics and strategy, the subject took into account more closely the actual strategic contingencies of the situation, determined by the combination of both the trial and the inequality of trial outcome variables. Thus, when required to set an earnings goal, to estimate the proportion of outcome that he expected the other bargainer and he would earn, and to specify the contracts he would propose, the subject's response was a function of both the trial variable -- S intended to bargain "harder" in the one-trial condition than in the ten-trial condition -- and of the asymmetry variable -- S intended to bargain "harder" when asymmetry was high -- so long as the outcome at stake was real money.

When the subject was to bargain for imaginary money, however, his strategic plans were primarily based on his "affective" orientation to the situation, rather than on the strategic contingencies.

These partial findings suggest some important empirical bases for the separation of affective and strategic influences in negotiation processes. A paper summarizing some of these findings is planned for the next reporting period.

A second S. WINSTON study has been incorporated into the Los Angeles Metropolitan Area Survey conducted by the U.C.L.A. Survey Research Center. At the closing phase of a structured interview, the respondent is told the following:

Here is a final set of questions I think you will enjoy. I am going to describe a situation for you, and I want you to imagine what you would do in this situation. Here it is. You have a new and relatively expensive TV set which broke down two weeks ago. Unfortunately, the guarantee had run out. Since you really like watching television, you are anxious to get the TV set fixed as soon as possible. Last week you called in two different repairmen to try to get a good price on the repair job. Both these men gave price estimates you thought were too high. Now you are taking your set to Mr. White, a Caucasian repairman who has a shop near your home. Mr. White looks at the set and tells you the repair will cost \$ \_\_\_\_\_. (The price schedule presented to each interviewee is adjusted to consider income and family size.) This is still more than you wanted to pay, although below the two previous estimates. You suspect that you might be able to get a better price from Mr. White if you try. On the other hand, if you suggest a much lower price, he might refuse to work on the set at all.

How much will you offer Mr. White to repair the TV?

He is then asked a number of questions which will reveal how intensely he would bargain in that situation, the influence tactics he would employ and his perception of himself and the repairman. Two variables are manipulated. 1) The effect of same versus different ethnicity on respondents bargaining plans. (The scenario describes the repairman as "Mr. Brown, a Negro", "Mr. Goldstein, a Jewish repairman", "Mr. Lopez, a Mexican-American or as noted in the above except.) 2) The effect of a firm or a flexible concession. (The counteroffer that the TV repairman makes to the respondent meets him half way or remains unaltered.)

The data should reveal a great deal about the perceptions of the sample to the situation and variables manipulated. Relatively no data of this kind has been systematically collected. Furthermore, if this technique of using experimental manipulation of variables in surveys proved of value, it will open up a largely untapped domain for data collection and hypothesis testing to augment those collected in the laboratory.

An error in sampling made by the Survey Research Center requires that the data be recollected this fall. These will be obtained for us at no additional charges. Further work on this project will be deferred until the data is obtained.

## FUTURE PLANS

This proposal reflects our plans to accomplish the program of research, as discussed in the project's original proposal, within the time period and funding schedules negotiated as terms of the basic contract. As reflected in our management and fund status reports to date, we have not requested a change or revision of these terms; and, based on projected plans, we are not, at this time, requesting any change. We recognize, however, that because delays associated with equipment arrival and facilities completion and because many of the project developments will come to greatest fruition in the last phase of the contract, the project may realize its goals more adequately if the contract completion date is extended so as to take maximum research use of supporting facilities that have been developed. To that end we will keep the agency closely informed of project progress, and will, if the developing situation warrants it, offer recommendations as to possible extensions of the termination date of the contract. Based on current developments, the projected plans for the Center are the following:

### Central Computer System

The computing system to support Phase I operations is now essentially complete. The exception to full operational capability is the light-pen; a prototype pen, delivered with the second shipment of terminals, was evaluated and is being re-designed for production model specification; the re-designed light-pen should be delivered in the first half of FY 1972.

A feasibility study on virtual memory has shown that segmentation can be implemented readily without obsoleting existing software. Virtual memory hardware and archive storage hardware required to support the Phase II operating system will be acquired and integrated into the system before the end of the

calendar year. In addition to the requirements for Phase I and Phase II operating systems, hardware to support remote users is also required. This equipment will be acquired in the next fiscal year.

#### Operating System (Phase I) Software

Phase I software developments are essentially complete; work in this area will be confined to maintenance and selective upgrading.

#### Operating System (Phase II) Software

The implementation of Phase II software will begin in July; its completion, of course, is dependent on the scheduled development of virtual memory hardware. Initial operational capability is projected for January 1972, with upgrading to follow on.

#### Higher Order Language Software

An operable JOVIAL compiler will be delivered early in fiscal year 1972; the compiler will be extended and upgraded during the ensuing eight months; and the full compiler will be maintained under contract for the ensuing twenty-four months. The META compiler will be extended and upgraded with special emphasis on increasing its capabilities to re-format data bases.

#### Laboratory Housing

The interim laboratory will be maintained until the permanent laboratory is operational. The permanent laboratory will be ready for occupancy by the end of this calendar year.



### Laboratory Equipment

Equipment to outfit the permanent laboratory will be acquired in the next six months; orders for off-the-shelf equipment will be deferred until the second quarter of fiscal 1972; all other orders will be placed in the first quarter.

### Laboratory Software

The laboratory programming system will be empirically tested, upgraded and augmented during the next six months; this will provide an operational version for initial use in the permanent laboratory.

The next phase of development is aimed at increasing the system's effectivity in three respects: The first is to test and improve the quality of user interaction in order to provide the most natural and expeditious interface possible. The second aspect of development concerns the augmentation of the basic system capabilities to provide improved investigator control and support during the course of experimentation -- on-line retrieval of information, real-time analysis of in-process data, interactive intervention and control of experimental condition settings and parameter, etc. The third aspect of development is directed at an evaluation of program efficiency to satisfy the real-time experimentation requirements in the interpretative mode of program execution. This would obviate the need to convert the specifications of each experiment into a special-purpose program. Empirical determination will be made under high-demand condition, i.e. involving the maximum number of interactive positions; this test will be deferred, then, until the operating system can service and support the full complement of communication terminals.

### Data Analysis/Management System

The formulation of the Basic TRACE III has been completed; coding has begun and component checkout of the initial system is scheduled for completion within three months of the delivery of a reliable version of JOVIAL. System checkout is scheduled for completion in the third quarter of fiscal year 1972. Formulations for extensions of Basic TRACE III will be completed by the end of calendar year 1971 with coding to follow directly after the completion of Basic TRACE III and checkout projected for the second quarter of fiscal year 1973. Maintenance and upgrading are scheduled for the remainder of the project. IDEA has been transferred to the PDP-10; parallel with its operation in FORTRAN IV, it will be converted to JOVIAL and interfaced with the Basic TRACE III data base system; this integration is scheduled for the third quarter of fiscal year 1972.

### Data Archives System

Some studies and evaluations in advance of formulation have already been completed; final studies will be completed early in fiscal year 1972 so that formulation can begin before the second quarter with completion scheduled before the third quarter, and (depending on the implementation of virtual memory capabilities) production of the data archives system beginning in the fourth quarter.

### Formulation of a Set of Simulation-Testable Propositions in Confrontation and Commitment Theory

With the completion of papers in both of these areas, plans for testing subsets of variables are being evaluated for simulation. Particularly regarding confrontation theory, the model is to be tested with a simulator by simulation. The implementation of this project is to be completed by the end of the year.

A Book on Scenario Design and Construction for International Relations Simulation Exercises

Review of three draft chapters and completion of two additional draft chapters are scheduled for completion in the first quarter of fiscal year 1972.

Two additional draft chapters on setting up and running simulation exercises are scheduled for completion during the second quarter.

A Mid-East Scenario for 1974 for a One-Team Simulation Exercise

The one-team simulation has been programmed for computer administration. The simulation has been programmed as a two role game -- one being the Subject role and the other being the Control or experimenter role. The experimenter controls the content of the situation displays to be presented to the player in each cycle of the simulation; the Subject makes the required type of responses for each cycle; and then the experimenter constructs the situation for the next cycle. Shake-down runs have been made; preliminary data has been used to revise and expand the scenario and associated techniques for on-line elicitation of decisions and responses. A series of experimental runs awaits the completion of the laboratory facility.

Computer Interactive Approach to Theme Encoding of Messages and Documents Generated in a Laboratory Setting

The level of effort on this task has been increased with the assignment of a full time staff member to this activity at the close of the present reporting period. Three basic sub-tasks are being pursued: 1) A study of the relationships between theme structures of the Stanford General Inquirer and elementary grammatical structures will lead to a description of the ways in which themes are represented in English sentences -- a thematic grammar, expressed in an augmented context-free framework. This thematic grammar should be approximately 50

complete at the end of the next reporting period. 2) A parsing algorithm of a well-understood context-free type, augmented with a number of systematic structure-manipulating devices will be developed to reduce spurious ambiguities and permit more efficient overall parsing strategies. A version of the algorithm will be running for experimental purposes by the end of the next reporting period.

The monitor must be sufficiently flexible to permit the concentration of interactive efforts where they are most needed and should take advantage of the fully automatic capabilities of the system where these are most reliable. The implementation of this interactive monitor should be initiated by the end of the six month period.

#### Direct Validity Tests of the Stanford General Inquirer

Experimental validity studies of the kind described will be initiated early in the next quarter and analyzable results will be available at approximately the end of the next reporting period.

#### All Computer Simulation Modelling of International Conflict

The initial successes of the lateral pressure model in predicting governmental and nongovernmental policy changes as manifested in external action variables will be pursued so as to bring the model up to date for prediction purposes on a few major powers. Indices will be defined and tested for some of the following: Technology, Capital Stock, Specialized and General Capabilities, Trade and Foreign Investments, and other external action variables. The validity and forecasting power of these models will be tested with alternate or multiple definitions, and time series data collected up to current times. Germany, Japan, U.S. and the Soviet Union will be given top priority so we can bring the pressure model up to future-predictive capability soon.

This effort will be supported at a reduced level (approximately one-half man-year) during the next fiscal year.

#### Experimentation

Analyses of data from earlier computer laboratory-based experiments will continue and results will be reported. Preliminary plans for experiments will be formulated in anticipation of the development of permanent laboratory facilities. These will be used as test cases for the "entry" module of the laboratory software system.

#### SCENQUEST - A Scenario Questionnaire Technique for Studying In-process Phenomenon in Conflict Resolution

Fresh bargaining data from the U.C.L.A. Survey Research Center will be collected in the autumn of 1971. Analysis of results will be initiated when these data are made available.

PROFESSIONAL AND PROJECT-RELATED ACTIVITIES

Professional Conferences, Presentations and Activities

Gerald H. Shure attended Meeting of Society for the Psychological Study of Social Issues, New York City. Briefing by United Nations Institute for Training and Research staff. Professor Alexander Szlalie. March 5-6.

Gerald H. Shure was chairman on Panel on Social Psychology Contributions to International Relations, International Studies Association (West). San Francisco, March 26-27.

Gerald H. Shure attended Rand Corporation Conference, Santa Monica. ARPA-sponsored gaming conference. March 29-31.

Al Cooperband, Reginald Martin, and Stuart Shaffer attended Southern California PDP-10 Computer User's Group, April 27.

Gerald H. Shure lectured on Simulation in International Relations, Brigham Young University. May 13-14.

Stuart Shaffer was Regional Representative on ACM Council. Spring Joint Computer Conference. May 17-21.

Gerald H. Shure met with Professor Philip Stone to discuss content analysis, and with David Armour on Data Management in Social Science. Harvard University; Dow Eytéma, MIT. Exchange of information on ARPA-sponsored research. June 21-22.

Gerald H. Shure attended National Science Foundation Conference on Computers in the Undergraduate Curricula. Dartmouth College. Met with Ed Myers, Dartmouth, to discuss interactive data management for social science. June 23-25.

Visitors to CCBS, Demonstrations and Meetings on UCLA Campus.

Dr. Hector Capello, Department of Psychology, University of Mexico, Mexico City, Mexico. Discussion of simulation and laboratory experiments of conflict. January 3, 1971.

Mr. Don Gondek, Rome Air Development Center, was briefed on developments within CCBS computing system, and on the CCBS approach to virtual memory. January 1971.

Mr. Al DeLucia visited CCBS for an informal review of project progress and a predistribution review of the third semi-annual technical report. February 8, 1971.

Professor O.K. Tikhomirov, Department of Psychology, University of Moscow. Discussion of simulation of problem solving. February 25, 1971.

Professor Morton Deutsch, Columbia Teacher's College, New York, New York. Discussion of experimental studies of conflict. March 11 and 12, 1971.

Professor Ronald Anderson, University of Minnesota. Discussion of CCBS data management concept for social scientists. March 17, 1971.

Professor Harold Geutzkow, Northwestern University, Evanston, Illinois. Discussion of simulation research. March 31, 1971.

Colonel Austin Kibbler, Acting Director of ARPA Behavioral Science. Briefing on CCBS program. April 1, 1971.

Mr. Al DeLucia, Contract Monitor's office. May 10, 11 and 12, 1971.

Mr. Frank Thomas, Christine Shube of Pacific Sierra Research Corporation, Santa Monica; Pat Langendorf, RADC, and George Lawrence, Deputy Director of ARPA, Behavioral Science. Discussion of potential laboratory simulation contribution to their project. June 2, 1971.

Professor Gerritt Wolf, Yale University. Discussion on on-line computer experimentation. June 10, 1971.

Mr. Gerald Plant, RADC, Contract Monitor's office. June 11, 1971.

Dr. Robert Young, Consolidated Analysis Centers, Inc., Arlington, Va. Reviewed various research and development activities in the CCBS project. June 28, 1971.

Post, J. L.: Functional description special communications interfaces for U.C.L.A. Digital Equipment Corporation, Maynard, Mass. October 20, 1970. (Included in appendix).

Post, J. L.: Functional description special communications interfaces for U.C.L.A. Digital Equipment Corporation, Maynard, Mass. October 20, 1970. (Included in appendix).

Shaffer, S. S.: Operating system user problems. Proceedings of the Association for Computing Machinery, SOLO Computer Conference, 1970, in press.

Shure, G. H.: Survey materials and items for scenquest bargaining study. November 1970. (Included in appendix).

Shure, G. H.: On-line computer techniques for data acquisition and inductive data analysis. Proceedings of the American Political Science Association, 1970, in press.

Shure, G. H., and Meeker, R. J.: A computer-based experimental laboratory, American Psychologist, 25, 10, 962-969, 1970.

Project Documentation, January - June 1971.

Abacus Programming Corporation: JOVIAL '70: Language Specifications (Preliminary), 1971

Baker, P.: The CCBS/PDP-10 System: Extended terminal read/write capability, 1971

Baker, P.: The CCBS/PDP-10 System: Cataloguer Description (Draft)

Cooperband, A.: The CCBS/PDP-10 System: TXTED -- A Simple Context Editor, 1971

Cooperband, A.: The TRACE-III Implicit Programming System: Algorithms for Arithmetic Functions in the TRACE Interpreter, 1971.

Cooperband, A. and Gallenson, L.: Multiple Virtual Memories for the PDP-10, 1971

Cooperband, A., Moore W., Meeker, R.J. and Shure, G.H.: TRACE-III: An Implicit Programming System for Inductive Data Analysis, 1971



DeWeerd, H.: The Contextual Scenario: What it is and how to use it. (Draft chapter for book, Simulation for International Relations). 1971.

DeWeerd, H.: How to write scenarios for international relations games. (Draft chapter for book, Simulation for International Relations). 1971.

Fisher, W.: The CCBS/PDP-10 System: Simplified User's Guide. 1971.

Lagerstrom, R.P.: "The Arms Race that Wasn't: US/USSR, 1951-1969," Memorandum 71-ICI-1, Institute of Political Studies, Stanford University, 1971.

Lagerstrom, R.P.: "Definitions of Resource Demand," Memorandum 70-ICI-1, Institute of Political Studies, Stanford University, 1970.

Lagerstrom R.P. and North, R.C.: "Germany and Japan: A Comparative Application of a Model of Expansion," delivered at the Western Political Science Association meeting, Albuquerque, April 8-10, 1971.

Meeker, R.J., Shure, G.H. and Cooperband, A.: LIS: A Laboratory Implementation System for Designing Computer-based Experiments. 1971.

Moore, W.H. and Cooperband, A.: The SMART Operating System: Debugger Specifications. 1971.

Moore, W.H. and Cooperband, A.: The SMART Operating System: Executive Procedures for Data Transfer. 1971.

North, R.C. and Lagerstrom, R.: War and Domination: A Theory of Lateral Pressure (New York: General Learning Press, forthcoming 1971).

North, R. C. and Lagerstrom R.P.: Development and Improvement of Software and Quantitative Data for the Refinement and Exercise of Two Predictive Models of International Conflict. Annual Report, 1971.

Rogers, M.S.: IDEA--A Program for Inductive Data Exploration and Analysis: A User's Guide to CCBS-IDEA. 1971

Robinson, T.: Alternative Regime Types: (Draft chapter for book, Simulation for International Relations), 1971.

Shure, G.H., DeWeerd, H. and Greenstein, S.: A Content Analysis Comparison of Four Simulation Exercises. (Draft). 1971.

Tripodes, P.: A Method for Sequential Coding of Content, 1971.

Weiler, D.: Building Descriptions of World Settings. (Draft chapter for book, Simulation for International Relations), 1971.

Wilkinson, D.O.: Confrontation Theory. 1971.